TechNote
PlasmaQuant MS Series: Eco Plasma

Eco Plasma – Innovative Inductively Coupled Plasma Technology

Introduction

Since the 1980s inductively coupled plasma (ICP) excitation sources are coupled to mass spectrometers to combine the advantages of a powerful excitation with a highly sensitive detection.

The ICP is typically an argon-based plasma generated inside a quartz torch, figure 1. It is ignited by a spark and sustained by an RF field generated in an induction coil. The advantage of an ICP is the hot enough temperature of about 7000 up to 10,000 K, which allows ionizing the majority of elements efficiently. Moreover it is a clean ionization source, since the ICP is electrodeless (contrary to Glow Discharge), and therefore the discharge never touches any surface.

Your Benefits

- Robust plasma performance using as little as 7.5 L/min plasma gas
- Low argon consumption saves about 50% of the plasma running costs
- Able to run any sample matrix from waste water to organic solvents without affecting performance

The argon plasma generated is electrically neutral and mainly creates single positively charged ions that can be detected with a mass spectrometer. It is a robust ionization source that handles different matrices from clean water to high matrix environmental and geological samples as well as pure organic solvents. This flexibility and robustness make ICP-based instruments so successful. Nevertheless, the high volume of argon consumed by conventional ICPs is challenging, especially for users in remote areas. The Eco Plasma in the PlasmaQuant MS series of instruments cuts argon consumption down to one half, depending on the application, without sacrificing the analytical performance of the instrument.

Cost-effectiveness of the Eco Plasma

Low argon consumption

An advanced proprietary configuration of coil and plasma reduces unnecessary overheating of the torch, hence decreasing the plasma gas flow significantly. This allows to run the PlasmaQuant MS systems on 7.5 to 10 L/min plasma gas compared to 16–18 L/min on conventional ICP systems, and without affecting plasma robustness and efficiency.

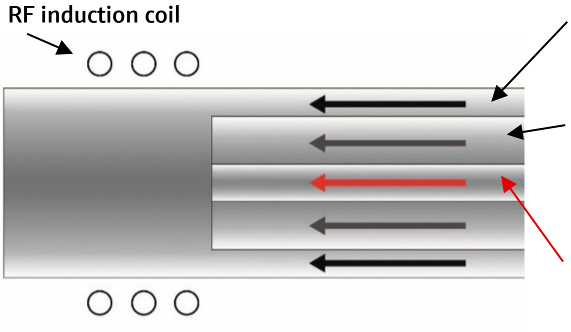

Figure 1: construction of the torch and gas flows

Outer tube
Plasma gas, also coolant or main gas, isolating the plasma from touching the torch, to prevent it from melting

Inner tube
Auxiliary or make up gas, forming the plasma and keeping it away from the injector tube.

Injector tube, introducing the sample into the plasma via the nebulizer gas flow

Nebulizer flow, forms a central channel that the sample passes and has a temperature even higher than any chemical flame

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany
Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Low power consumption

The plasma moves relatively slow through the torch, with an auxiliary argon flow speed of 1 to 1.5 L/min. This results in a longer residence time τ within the RF coil for more efficient energy transfer from coil into the plasma. This generally leads to a higher working temperature of the plasma while at the same time reducing power consumption. Under regular working conditions the PlasmaQuant MS system runs on less than 2.0 kWt to deliver a 1.2 kW plasma (single phase).

Efficiency of the Eco Plasma

The PlasmaQuant MS series of instruments by Analytik Jena features a unique plasma RF system that guarantees a robust plasma for efficient ionization of various matrices from water to organic solvents, from very clean samples up to samples containing high amounts of total dissolved solids.

The free-running, solid-state RF generator used on the PlasmaQuant MS has been specifically developed to meet the requirements of the ICP-MS:

- High coupling efficiency of >85%
- Delivering 300–1600 W power on plasma for high flexibility in applications
- Permanent monitoring of forward RF power and automatic adaption of frequency upon impedance change due to sample matrix for constant power delivery

Ionization efficiency

A common performance criteria for plasma systems is the efficiency of coupling the energy into the plasma, that means the efficiency of ionization at a low formation of plasma-based molecular ions like oxides and of double-charged ions. The performance is measured by the % formation of CeO^+ versus Ce^+ and Ba^{++}/Ba^+ or Ce^{++}/Ce^+. All ratios should be well below 2 and 3% although much lower oxide formation can be achieved by sacrificing sensitivity. The Eco Plasma in the PlasmaQuant MS instruments already allows a good analytical performance at oxide levels of 0.5%, however maximum sensitivity is obtained at approximately 2% CeO^+/Ce^+ formation.

Selectable power delivery for application flexibility

Depending on the matrix and analytes of interest, a variation of the plasma power within a method can lead to optimum performance for the desired application. Some applications run at very low power settings with 600 to 800 W, others require a very hot plasma at 1.5 to 1.6 kW. The wide power range of 300–1600 W delivered from the PlasmaQuant MS' RF generator allows individual adaptation of the plasma.

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Constant performance for a complete ionization

To guarantee a constant performance for the complete ionization of various samples the plasma needs to adapt to varying matrices. Therefore, the forward RF power is permanently monitored. In case of an impedance change due to the sample matrix the frequency is instantaneously adapted automatically.

Plasma robustness of the Eco Plasma

A plasma is considered robust when different matrices do not cause the plasma to extinguish. The Eco Plasma tolerates 100% pure organic solvents without limitations as well as high TDS samples like 3.5% NaCl. Please see figure 2 to 5 showing the Eco Plasma under various conditions.

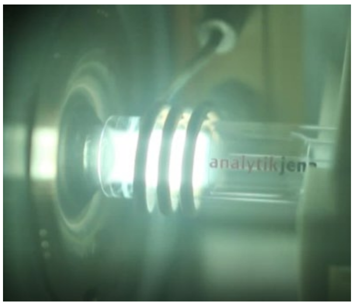

Figure 2: Hot plasma at 1.5 kW

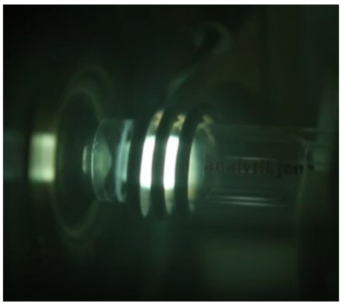

Figure 3: Cool plasma at 600 W

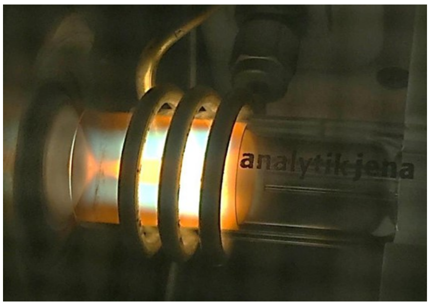

Figure 4: Hot plasma with high TDS sample

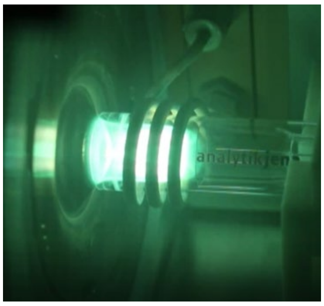

Figure 5: Plasma with 100 % ethanol

Application examples

Seawater: gas settings and results of a five hours stability test for 1 ppb spike in 1:10 diluted Portuguese seawater.

Table 1: plasma settings

Parameter	Specification
Coolant Gas Flow	10.5 L/min
Auxiliary Gas Flow	1.50 L/min
Injector Gas Flow	1.08 L/min

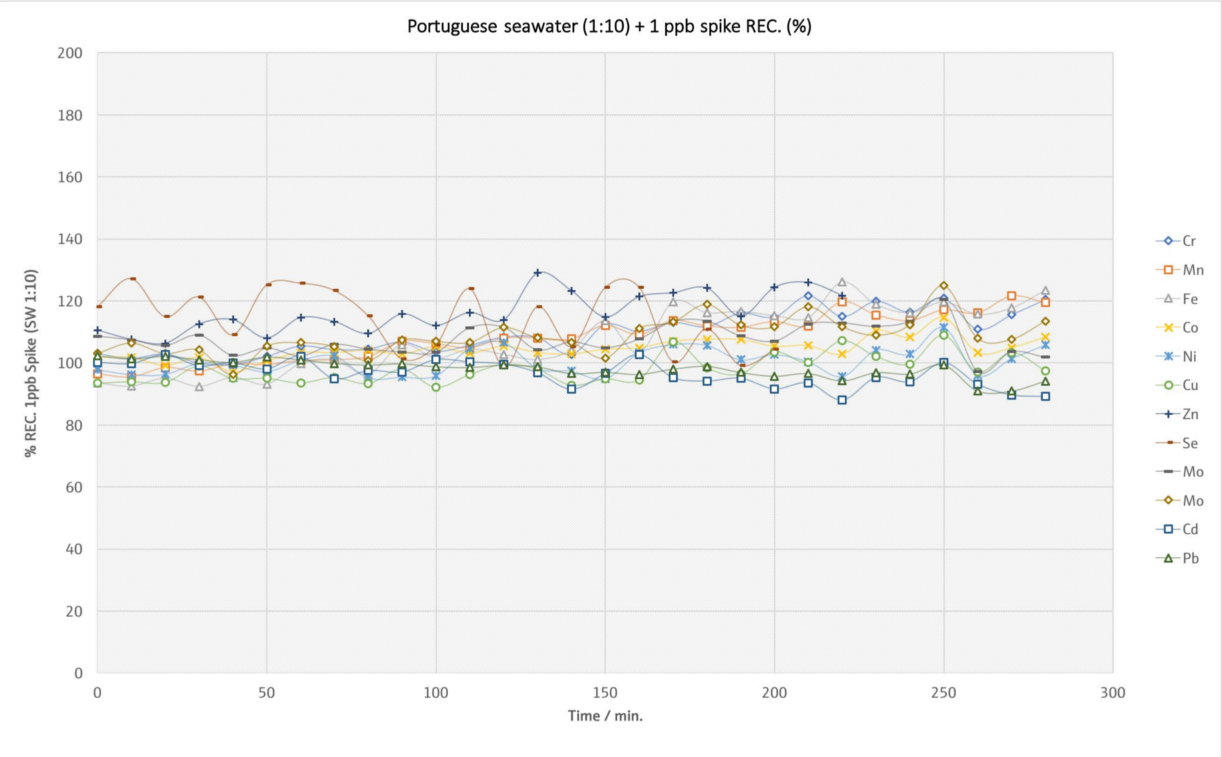

Figure 6: display of the results of the stability test

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

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Drinking water: gas settings and results of a 7 hours stability test for drinking water

Table 2: plasma settings

Parameter	Specification
Coolant Gas Flow	9 L/min
Auxiliary Gas Flow	1.45 L/min
Injector Gas Flow	1.01 L/min

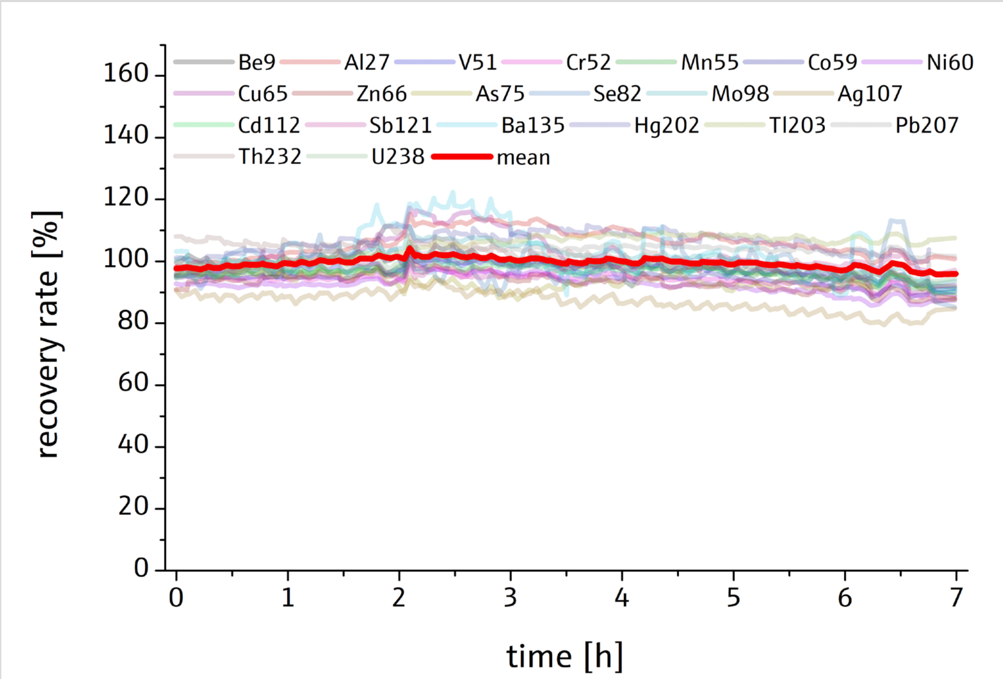

Figure 7: Recovery rate of the certified reference materials and LFMs as a function of time.

Conclusion

ICP-MS instruments are widely used and support analytical tasks in various application fields. An inductively coupled plasma therefore needs to efficiently ionize a variety of matrices and tolerate different solvents without affecting the analytical performance of the whole instrument.

The unique technology of the Eco Plasma used in the PlasmaQuant MS, ICP-MS instruments for the first time offers an ionization source that combines highest analytical performance with low Ar consumption. Using the Eco Plasma saves about 50% of the plasma running costs.

References

1) Application Note PlasmaQuant MS "Determination of Trace Elements in Seawater using ICP-MS"
2) Application Note PlasmaQuant MS "High-throughput Analysis of Drinking Water with ICP-MS"

Further information

For further updates, applications and other literature, please visit the Analytik Jena website at www.analytik-jena.com.

Reference: TechNote_ICP_MS_0001_en.docx

Analytik Jena GmbH
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